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Evaluation of Transportation Control Measures for Federal and State Ozone Plans

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Introduction

This report is intended to provide helpful information on gauging emission reduction benefits from various types of Transportation Control Measures (TCMs) that can be considered for federal and state ozone plans. One of the main purposes of the report is to provide a more comprehensive understanding of emission reductions and costs for those measures that have received recent attention as part of the current ozone planning process. The report builds on earlier analyses of Further Study Measures in the 2001 Ozone Attainment Plan and on additional screening of Reasonably Available Control Measures. The analysis is based on the best available assumptions. Where possible, an effort is made to use real world examples or rely on relevant information that has been previously developed. By quantifying the emission reduction benefits of certain categories of measures, it will be easier to assess the potential benefits of other measures that might fit under these categories.

Information for each measure is grouped according to the following topics:

- Description/Market Served
- Background
- Methodology and Key Assumptions for Calculations
- Emission Reductions
- Cost Effectiveness
- Other Benefits/Impacts

Most of the topics above are fairly self explanatory. Displaying the emission assumptions provides better insight into how the reductions were derived. The cost effectiveness information includes capital and operating costs, where available, which can be compared to the amount of emissions reduced-- recognizing that for many transportation measures the air quality benefits may be secondary to improved mobility. The discussion of other benefits/impacts conveys information on non air quality related factors which may be important in determining whether to further consider certain measures.

The selection of new measures for federal and state plans will ultimately depend on the Bay Area’s attainment status and projected level of further emission reductions needed to achieve the ozone standards. The process for making these determinations is still underway

Bay Area Travel and Mobile Source Emission Projections

- Motor vehicle emissions are calculated by knowing the number of vehicle trips, amount of vehicle travel that takes place (VMT), and the speed of travel. Transportation control measures may affect one or more of these factors to reduce motor vehicle emissions. The analysis year for most of the calculations is 2006, meaning that the emission characteristics of the vehicle fleet are those for 2006. Mobile source emission factors are from the California Air Resources Board (EMFAC2002 V2.2 Apr 23, 2003). Some of the key statistics are shown in the attached Figures at the end of the report.
- Figure 1 shows the daily regional vehicle trips in 2006
- Figure 2 shows daily weekday vehicle miles of travel in the region

- Figure 3 shows average emission rates for the Bay Area vehicle fleet in 2006
- Figure 4 shows how emission rates change with average speed
- Figure 5 shows the calculated mobile source emission inventory for VOC, one of the chief precursors of ozone
- Figure 6 shows the same for NOx, one of the chief precursors of ozone
- Figure 7 shows the composition of mobile source VOC emissions by various categories of emissions: Start and Soak, and Running
- Figure 8 shows the same for NOx

Measure 1 : Enhanced Bus

Description/Travel Markets Affected

Enhanced bus is a type of service that employs modest schedule optimization techniques together with increased bus frequencies to provide a higher quality of service. Typical improvements include relocated bus stops, signal priority for buses when buses are behind schedule, improved shelters and signage, and real time schedule information. New riders would be attracted to transit through more frequent and reliable service and would include both work and non work trips.

Background

Several Bay Area transit operators have funded or proposed Enhanced Bus routes: AC Transit, Muni, and VTA. For some routes associated costs and ridership estimates have been developed.

Methodology and Key Assumptions for Calculations

The analysis is based on four routes proposed by AC Transit and uses the cost and ridership information developed by AC Transit for these routes: Foothill/MacArthur, Shattuck/Alameda; MacArthur/Airport; College/University. New riders include both choice riders as well as riders who do not own a car, and therefore, would not contribute to additional emission reductions (a 63% transit dependent share was assumed based on AC Transit estimates*)*. The length of the bus trip was assumed to be a little over three miles. Access to the bus would be primarily by walk/bike, but there would be some minor amount of auto access as well. There will be some increased emissions created by the added buses required for the new service.

Route	Annual Estimated New Riders	Estimated New Daily Riders	New Daily Riders Minus Transit Dependant Riders
Foothill/MacArthur	1,672,800	5,179	2,020
Shattuck/Alameda	1,116,000	3,455	1,347
MacArthur/Airport	2,960,100	9,164	3,574
College/University	3,501,000	10,839	4,227
Totals	9,249,900	28,637	11,169

Mode of Access	Transit Access Mode Percentages	Trips	VMT Displaced
Vehicle Driver	14.8%	1,653	4,876
Vehicle Passenger	5.1%	570	1,680
Bicycle	0.5%	56	165
Walk (Linked)	50.9%	5,685	20,750

Other	0.2%	22	82
Walk (Unlinked)	28.5%	3,183	11,619
Totals		11,169	39,172

- Average transit trip length equal to 3.3 miles
- Off-set transit access mode emissions included

Emission Reductions.

- **0.0600** tons per day of VOC
- ***increase*** of **.0066** tons per day NOx

Cost Effectiveness

- Capital cost for four routes: $132,750,000
- Annual net operating cost for four routes: $7,319,000
- Cost per ton reduced of VOC and NOx: $ 1,105,700 ($553 per pound)

Assumptions: capital recovery factor for 14 yrs (life of buses) of .08853; AC Transit rider annualization factor of 323; emission reductions are sum of VOC decrease and NOx increase

Other Benefits/Impacts

The buses would have NOx and PM reduction devices. Several of the enhanced bus routes would serve minority and local income neighborhoods and are on MTC's Lifeline Transit Network.

Measure 2: Bus Rapid Transit

Description/Travel Markets Affected

Bus Rapid Transit (BRT) is a further improvement in the Enhanced Bus concept, generally involving a higher level of capital investment to separate bus operations from normal traffic. BRT may include dedicated lanes, more substantial stops and shelters, real time arrival information, and signal priority. The buses may be frequent enough that schedules are not required. The scale of the investments is such that they would normally be made in corridor with high levels of existing transit riders. To the public, the service would seem quite similar to that have a light rail vehicle. Like Enhanced Bus, new riders would be attracted through more frequent and reliable service and include both work and non work trips.

Background

Several Bay Area transit operators have proposed Bus Rapid Transit, either as an evolution of an Enhanced Bus route or as an initial project: AC Transit, Muni, and VTA. For some routes associated costs and ridership estimates have been developed

Key Assumptions for Calculations

The analysis is based on four routes proposed by AC Transit and uses the cost and ridership information developed by AC Transit for these routes: Foothill/MacArthur, Shattuck/Alameda; MacArthur/Airport; Telegraph/East 14th/International. New riders include both choice riders as well as riders who do not own a car, and therefore, would not contribute to additional emission reductions. The length of the bus trip was assumed to be a little over three miles. Access to the bus route would be primarily by walk/bike, but there would be some minor amount of auto access as well. There will be some increased emissions created by the added buses required for the new service.

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Route	Annual Estimated New Riders	Estimated New Daily Riders	New Daily Riders Minus Transit Dependant Riders
Foothill/MacArthur	1,080,000	3,344	1,304
Shattuck/Alameda	787,200	2,437	950
MacArthur/Airport	525,000	1,625	634
College/University	518,400	1,605	626
Totals	2,910,600	9,011	3,514

Mode of Access	Transit Access Mode Percentages	Trips	VMT Displaced
Vehicle Driver	14.8%	667	1,967
Vehicle Passenger	5.1%	230	678

Bicycle	0.5%	23	82
Walk (Linked)	50.9%	2,294	8,371
Other	0.2%	9	33
Walk (Unlinked)	28.5%	1,284	4,687
Totals		4,506	15,819

- Average transit trip length equal to 3.3 miles
- Off-set transit access mode emissions included

Emission Reductions.
- **0.0189** tons per day of VOC
- ***increase*** of **0.0021** tons per day NOx

Cost Effectiveness
- Capital cost of four routes: $828,950,000
- Annual net operating cost of four routes: $13,267,000
- Cost per ton reduced of VOC and NOx: $ 15,968,960 per ton ($7,985 per pound)

Assumptions: same as previous measure

Other Benefits/Impacts

The buses would have NOx and PM reduction devices. Several of the Bus Rapid Transit routes would serve minority and local income neighborhoods and are on MTC’s Lifeline Transit Network.

Measure 3: Downtown Shuttles

Description/Travel Markets Affected
Downtown shuttles may either provide connections between the downtown and a nearby transit station or provide circulation between downtown businesses, thus reducing the need to use a car for short trips. Shuttles offer users several conveniences, such as avoiding downtown traffic, having to find parking space, or paying for on street parking. There may be some work trips involved, but the majority of the trips would likely be shopping or mid day trips from a work location to nearby shops, restaurants, banks, etc.

Background
Several cities have operated downtown shuttles, including Oakland, Walnut Creek, and Emeryville. Average daily ridership was: 820 (Walnut Creek), 1,600 (Broadway), and 2,500 (Emeryville). Shuttles are difficult to finance on a self sustaining basis and some services have been discontinued due to lack of funding.

Methodology and Key Assumptions for Calculations
The key to the analysis is the number of auto trips that would be eliminated due to the downtown shuttle service. It is likely that in some cases the shuttle trip would have been made on an existing transit service or by walking, or not at all, if the trip was too inconvenient. For this reason, we assumed that 45% of the trips were former walk trips, 45% of the trips replaced a car, and 10% of the trips were attracted to transit and replaced a longer commute trip by car. Most of the trips would be relatively short (one and a half miles, or less) in length. The calculation is based on a total shuttle routes carrying 4,920 (??) passengers a day In addition, there will be increased emissions from the shuttle vehicle themselves which offset the emission reductions from elimination of auto trips
Emission Reductions.

- **0.0058** tons per day VOC
- **0.0050** tons per day NOx

Cost Effectiveness
The cost of a contracted downtown shuttle service would be $600,000 to $900,000 a year ($50-$75 per hour of service) for a "typical" operation: 1 route, 4 vehicles, 12 hours a day, 5 days a week.

- Cost per ton reduced of VOC and NOx: $213,675 per ton ($107 per pound)

Assumptions: Use low cost contract number which includes leasing, maintenance, and operation; 260 days of operation a year.

Other Benefits/Impacts
The shuttles would provide economic benefits to retail businesses by making them more accessible to nearby workers and area residents.

Measure 4: Shuttles to Transit

Description/Travel Markets Affected

Existing Bay Area shuttles provide important links between transit hubs and nearby businesses. There are more than 170 shuttles throughout the Bay Area, most of which operate to and from transit stations and nearby employment centers, universities, and medical centers. Shuttles to transit are designed to complement existing fixed route services, generally by filling in spatial or temporal gaps in service, or by providing more direct, limited stop service. Many of the trips are work oriented, as shuttles provide that “last mile” connection to complete a trip.

Background

The vast number of existing shuttles connect to BART, Caltrain (52 routes), and the San Joaquin ACE commuter rail service (where shuttles carry about 42 % of the riders to their final destination in Silicon Valley). Shuttles generally operate during the peak period. A particular shuttle service may have multiple routes. Caltrain shuttles carry about 6,000 riders a day.

Methodology and Key Assumptions for Calculations

The analysis is based on the Caltrain shuttle system. Shuttle trips from transit would be relatively short, less than five miles. The shuttle service would generally attract employees who would normally have used an auto to get to work. The average length of the commute trip was assumed to be 17.3 miles, reflecting the longer trips occurring on rail systems. It is assumed that new shuttles would be low emission vehicles.

- Assume shuttle riders are commuters who would have used a car instead of transit
- 17.3 mile work trip length between home and workplace
- Passenger vehicle mix: 90% LDVs and 10% SUVs

- Assume 12 new employer shuttle routes with 800 riders per route for a total of 9,600 new daily riders

Emission Reductions.

- **0.136** tons per day of VOC
- **0.199** tons per day NOx

Cost Effectiveness

Assuming fully contracted service, 12 employer routes would cost about $1.1 to $1.6 million per year. This is based on each route having 1 vehicle, operating 7 hours a day for five days a week.

- Cost per ton of VOC and NOx reduced: $12,630 per ton ($6.30 per pound)

Assumptions: lower cost, which includes all leasing, operating and maintenance costs; 260 days per year

Other Benefits/Impacts

The shuttles would provide local circulation benefits by removing some peak hour traffic from local streets.

Measure 5: New School Bus Service

Description/Travel Markets Affected

Many school districts have had to eliminate district-supplied school bus service in the face of growing budget pressures. School children in grades K-12 must then find alternative means to get to school, either using the public bus, getting dropped off and picked up by parents, driving or carpooling with fellow students, or biking/walking (if students live close enough to school). Some auto trips would be eliminated by re-instituting a school operated system that picked up students close to their home and dropped them off at school.

Background

MTC evaluated the potential costs of setting up school bus programs for those districts in Alameda County and described the results in a separate memo. Seven districts continue to provide service, and ten districts do not. A particular focus for this analysis was the Livermore Valley Joint Unified School District, which was used as a test case for the purpose of calculating costs and emission reductions.

Methodology and Key Assumptions for Calculations

Most districts with school buses do not serve children who live within one mile of a school. This factor reduces the eligible participants. For the Livermore District (K-8), with an enrollment of 9,000 pupils, it was assumed that 10% of the student population would take the school bus, based on a comparison with districts that currently provide home-to-school service and have similar demographic characteristics. Each student would generate two auto roundtrips a day, assuming the parents brought them to school and then picked them up. Trip lengths would be relatively short (average 2 miles in length).

Vehicle Type	Total VMT Replaced	Total Round Trips Replaced (per school day)
Clean Bus	3,956	1,978
Conventional Bus	3,956	1,978

Emission Reductions.

Auto Emissions			Bus offset emissions		Net Emission Reductions	
Bus Type	ROG	NOx	ROG	NOx	ROG	NOx
Clean	0.00477	0.00334	0.00001	0.00016	0.00476	0.00318
Conventional	0.00477	0.00334	0.00005	0.00077	0.00472	0.00256

**** Emissions in Tons Per Day**

Cost Effectiveness

Assuming the school district contracts out service to a third party, it would cost between $45,000 to $54,000 per bus per year. It is estimated that a Livermore school district service would require 12 buses; therefore, the costs would range between $540,000 and $648,000 per year (for some existing services, parents contribute to the operation to help defer costs to the school districts).

- Cost per ton of VOC reduced: $177,400 per ton ($89 per pound)

Assumptions: Use lower contract service cost and 200 school days per year (source: CARB)

Other Benefits/Impacts

The school buses would relieve local traffic at and around the school and would provide a safe means of transportation for school children.

Measure 6: New Ferry Service

Description/Travel Markets Affected

New ferry service would reduce the number of transbay auto trips between the East Bay and San Francisco and between parts of the Peninsula and San Francisco. The service would be targeted to selected geographic areas where there would be a high potential to attract new riders to transit. New vessels would be fast and frequent, with convenient feeder bus connections. The primary market would be work trips, although certain routes would be expected to have a robust non-work/recreational component.

Background

Expansion of ferry service on the Bay has been studied by the Water Transit Authority, a new transit agency created by the Legislature to plan and operate new routes. The WTA has developed and adopted an Implementation and Operations Plan which identifies new route opportunities and their costs. The Plan recommends six initial routes for operation: Pittsburgh/Antioch/Martinez to SF; Hercules/Rodeo to San Francisco (SF); Richmond to SF; Berkeley to SF to Mission Bay; South San Francisco to SF, and Redwood City to SF. Some of these routes could be funded through new state legislation requiring voter approval of a $1 increase in bridge tolls.

Methodology and Key Assumptions for Calculations

The analysis is based on the WTA's ridership projections. While the projections are for somewhat distant years, it is assumed that these ridership levels would occur in 2006. After adjusting the forecasts for riders who switch from another transit mode, the rest of the ferry riders are assumed to be diverted from single occupant autos. The WTA has also estimated the number of riders using various access modes used to get to and from the terminals, and these mode splits were used in the emission calculations. The ferries themselves will produce some level of emissions, although the WTA plans to acquire vessels that are even cleaner than EPA's standards. Calculations account for the increased bus emissions which would be generated by new feeder bus service to the terminals.

Ferry Route	Walk	Drive	Transit	Total Trips
1 [CC] Pittsburg/Antioch - Martinez - San Francisco	18	1,496	14	
2 [CC] Hercules/Rodeo - San Francisco	129	464	107	
3 [CC] Richmond - San Francisco	164	1,076	95	
4 [Ala] Berkeley - San Francisco - Mission Bay	18	1,342	408	
5 [SM] Oyster Point (South San Francisco) - San Francisco	96	1,619	157	
6 [SM] Redwood City - San Francisco	57	965	44	
	482	6,962	824	8,268

- Average trip length is 20 miles
- Assume 25% of ferry riders are from another transit system, and the rest used a car

Emission Reductions.

- **0.1498** tons per day VOC
- **0.1752** tons per day NOx

Cost Effectiveness

The WTA estimates were used for capital and net annual operating costs.

- Capital cost for six routes, including vessels and terminals: $175,000,000
- Net annual operating cost for six routes: $90,000,000
- Cost per ton of VOC and NOx reduced: $1,127,390 per ton ($564 per pound)

Assumptions: 30 year annualization of capital costs (.05102); 270 annualization factor for riders (source Chuck-GG Ferry)

Other Benefits/Impacts

Ferries would serve a vital transportation role in the event of an earthquake that damages one or more Bay bridges. New terminals provide an opportunity for transit oriented development around the terminals.

Measure 7: New Rail Extensions

<u>Description/Travel Markets Affected</u>

This analysis focuses on possible new rail services in three highly congested corridors: Marin-Sonoma (SMART), Route 4 (eBART), and I-580 in the Tri-Valley (tBART). These rail services would provide an alternative to auto travel for longer distance auto trips and would have secondary air quality benefits to the extent that the diversion of corridor travelers to rail helps improve freeway operations and reduces highway emissions in the corridor. It is anticipated that initial service would focus on the commute period and work trips, and off peak service for non work trips would be more limited.

<u>Background</u>

All three rail corridors are in various stages of detailed study and analysis. Full funding has not yet been identified for these rail expansions, although a combination of new bridge tolls and county sales tax measures, if passed by the voters, could make their implementation more likely. The services envision lower cost Diesel Multiple Unit (DMU) rail technology on standard railroad tracks. Stations would be located at key ridership hubs, and service frequency would depend on the amount of operating funds available.

<u>Methodology and Key Assumptions for Calculations</u>

Ridership estimates are based on the most recent studies, and future year forecasts are assumed to occur in 2006: tBART (2,240 daily *new* trips on transit); eBART (7,000 daily new trips), and SMART (5,090 daily transit trips). Because eBART and SMART are total transit riders, rather than new riders, a portion of the riders are assumed to be shifted from existing transit services in the corridor (15%). Trip lengths on SMART would be similar to Caltrain, whereas those on eBART and tBART were assumed similar to BART. Emissions for the rail vehicle are assumed to be based on the most advanced engine technology.

- Assume work trips on transit are shifted from autos
- Average trip length for tBART and eBART is 12.9 miles and average trip length for SMART is 17.3 miles

<u>Emission Reductions</u>.

- **0.1005** tons per day VOC
- ***<u>increase</u>*** of **0.0700** tons per day NOx

<u>Cost Effectiveness</u>

Costs are from the 2001 Regional Transportation Plan and MTC Resolution 3434.

- Capital costs for three new rail services: $890,000,000
- Net annual operating costs: $14,000,000
- Cost per ton of VOC and NOx reduced: $6,493,000 per ton ($3,246 per pound)

Assumptions: 30 year annualization factor (.05102); Caltrain rider annualization factor is 298 and BART is 303, so use 300

Other Benefits/Impacts

New rail systems could lead to increased economic development around rail stations and stimulate the local economy during construction. New stations provide opportunities for transit oriented development. Some of the mobility benefits would extend considerably beyond the date of initial operation as the corridors in which these systems operate become even more developed and congested.

Measure 8: Real Time Transit Information

Description/Travel Markets Affected

Transit agencies of various sizes are beginning to invest in real time bus and train arrival information for their customers. This capability is made possible by Automatic Vehicle Location (AVL) technology, which can identify the precise location of a transit vehicle. This information is then used by other software to calculate the arrival time of the transit vehicle at the next stop. The arrival information is conveyed to the customer through various types of electronic signs. Increased transit ridership would be an indirect benefit of these systems, and would result from improved customer perceptions about the transit system's convenience and quality of service. People traveling at night would also feel more secure when they have accurate bus arrival information. The market would be both commute trips as well as non-work trips.

Background

MTC has surveyed all Bay Area transit operators to determine the status of programs to develop real time arrival information.. Real time transit information is currently being provided by BART, Muni (light rail and 22 Fillmore line), and on AC Transit's San Pablo enhanced bus corridor (50 display units). Other operators in the Bay Area are in various stages of exploring AVL technology. Over time it is expected that the systems will be deployed in greater numbers, affecting a larger percentage of regional transit users.

A literature search shows only limited data correlating transit ridership increases to the presence of real time arrival information, and what data does exist may not be directly transferable from one area to another (according to TCRP report Synthesis 48, customer reaction to real time bus arrival information has been positive among the transit operators surveyed; however, none has reported a definitive increase in ridership as a result of deploying such a system). Where ridership did increase, it was difficult to determine whether it was a direct result of the real time information system.

Methodology and Key Assumptions for Calculations

Impacts on transit ridership could range from nil (0%) to 5% (based on European data which may not be transferable to the US). Assuming real time information would be applied first to the most heavily used transit routes, emission calculations were made by assuming positive ridership increases of between 1% and 5%. These increases were applied to the region's seven most heavily used bus routes (all Muni routes), with daily ridership of between 26,000 and 53,000 daily riders (243,000 total daily riders). The assumed percentage ridership increases were then discounted by the number of transit dependent riders who do not own cars and would not contribute to further emission reductions (50% of the riders, based on CARBs methodology. Assumptions were also necessary as to mode of access to the bus routes. Bus emissions were also factored in, since these routes are already crowded, and additional riders would translate into the need for more buses.

Emission Reductions.

- A range of **0.0067** to **0.0336** tons per day VOC
- A range of **0.0033** to **0.0166** ***increase*** in tons per day NOx

Cost Effectiveness

AVL based real time information systems can have widely ranging costs, depending on the size of the system deployed. Muni's initial investment for the light rail system and the Fillmore 22 line was $9.5 million in capital costs with an estimated $1.3 million in annual operations and maintenance cost. The next phase would extend real time travel information to the trolley coach lines ($3.5 million) followed by the motor coach routes ($4.5 million). Initial start up operations for VTA and LAVTA have been estimated at about $3million. For the purposes of the cost effectiveness calculation, the $3.5 million Muni figure was assumed as a proxy for real time information on the seven Muni routes above. This measure would have to be evaluated as a VOC control strategy only, since the NOx emissions from the new buses to carry the new riders are higher than the VOC reductions.

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- Cost per ton reduced of VOC: $698,300 per ton ($349 per pound)

Assumptions: Use highest ridership gains; annualization period of 5 years (similar to signals) with a factor of 0.2184 but no costs attributed to the added buses; Muni rider annualization of 304

Other Benefits/Impacts

As discussed above, there is improved customer satisfaction with transit and improved visibility of transit in the community. Also public bus operators have improved control of their system with accurate real time information on the location of all their vehicles. Deployment of this technology could incrementally increase transit operating and maintenance costs, and create capital expenditures for new buses to carry the new riders.

Measure 9: Transit Priority at Signals

Description/Travel Markets Affected

This type of strategy would grant transit buses priority at signalized intersections if the bus is running behind schedule. In a centralized system the dispatcher would activate the priority system. In a decentralized environment, the bus operator would activate the priority treatment. In both cases, closer adherence to schedules would generate a positive trip experience by providing more predictable travel times. Like the real time travel information, the user would generally perceive the strategy as an improvement in transit service. Both work trips and non-work trips would be affected. Because this measure would have similar effects on ridership and emission reductions as the previous Real Time Transit Information measure, the calculations are also based on providing transit priority treatment on the region's seven busiest bus routes, which are operated by Muni.

Background

AC Transit has analyzed the technical requirements for transit priority streets in enhanced bus corridors and is implementing the system on the newly operating San Pablo line (Route 72). .

Methodology and Key Assumptions for Calculations

The methodology is the same as for the real time transit information systems above, including assumptions about the percentage of riders who are transit dependent and the need to consider emissions created by adding new buses to these seven routes.

Emission Reductions.

- A range of **0.0067** to **0.0336** tons per day VOC
- A range of **0.0033** to **0.0166** ***increase*** in tons per day NOx

Cost Effectiveness

Studies of the cost of providing signal priority treatment show wide ranges in cost, between $8,000 to $35,000 per signalized intersection depending on a number of factors. For the purpose of this calculation a rough estimate was made of the number of signalized intersections along the seven Muni routes, and a cost of $14,000 per intersection was applied. This measure would have to be evaluated as a VOC control strategy only, since the NOx emissions from the new buses to carry the new riders are higher than the VOC reductions.

- Capital cost: $4,000,000
- Cost per ton reduced of VOC:$432,050 per ton ($216 per pound)

Same assumptions and issues as per previous measure. No costs were attributed to the added buses needed to carry more riders.

Other Benefits/Impacts

As discussed above, there would be improved customer satisfaction with transit. If there is a consistent and predictable reduction in travel time, fewer buses may be required to serve any given route, lowing transit operator costs. There would also be less wear and tear on buses from fewer stops and bus emissions may also decrease. Finally, there could be some minor impact on side street traffic, causing increased delays, due to giving buses priority at signals.

Measure 10: Regional Vanpool Program

Description/Travel Markets Affected

Ridesharing services operated in the Bay Area have resulted in about 864 formal vanpools operating today, carrying about 9,000 riders. Emission reduction estimates have been made for this regional vanpool program. Vanpools generally serve longer commute trips. Riders typically assemble at a pre-determined location. Vanpools use carpool lanes where they are available to save travel time. Operating costs are largely covered by the riders. Each vanpool eliminates auto trips, and the emission reductions depend on the former mode of travel used to make the trip, i.e., whether riders come from a single occupant vehicle, transit service, or carpool. Vanpools largely serve the work trip market.

Background

Rides for Bay Area Commuters (RIDEs) has been assisting commuters in forming vanpoolers for over 20 years. Recent efforts have focused on increasing the effectiveness of their placement services. A continuing part of their work is the refilling of vanpools when members drop out; therefore, retaining the existing number of vanpools in operation involves a significant amount of effort as well.

Methodology and Key Assumptions for Calculations

Data for the vanpool calculations was obtained from RIDEs. In addition to trip length, the other important factors are former mode of travel and how vanpool riders get to and from their collection point. Driving to the vanpool collection point generates auto trip start emissions and short distance travel emissions. The vanpools themselves create emissions which must be factored into the calculation. The basic assumptions are:

- 864 vanpool vehicles in the Bay Area
- Average vanpool size of 10.5 persons
- Average trip length of 49.2 miles

From the RIDEs' 1999 Vanpool Survey, trips and VMT were allocated according to mode to vanpool pick-up location.

Vanpool Access Mode	Percent	Trips	Displaced VMT
Picked up or walk	17.2%	1,562	76,833
Carpool	6.6%	596	29,312
Bicycle	0.9%	81	3,997
Drive Alone	74.2%	6,734	331,315
Transit	1.1%	99	4,885
		9,072	446,342

Emission Reductions.

- **0.3353** tons per day VOC
- **0.3519** tons per day NOx:

<u>Cost Effectiveness</u>
Administration of the existing regional vanpool program is through RIDEs. Generally the riders in the van pay a monthly fee which helps defray the lease costs, which may or may not include insurance and gas. The average cost per month is about $150 per rider, with costs increasing for longer commutes. Thus, the current users pay roughly $16 million per year to vanpool, which is used as the cost of operating the vanpools.

- Cost per ton of VOC and NOx reduced: $90,670 per ton ($45 per pound)*

Assumptions: 260 work days per year; 9,000 riders x 12 x $150 = $16.2 million annual cost.
* since the users essentially pay for the vans, the public subsidy is minimal

<u>Other Benefits/Impacts</u>
Energy savings are an important aspect of vanpools as they reduce the number of long distance vehicle trips. Also, in certain corridors, vanpools using carpool lanes can be a significant factor in reducing peak hour vehicle trips.

Measure 11: HOV Lanes and High Occupancy Toll Lanes

Description/Travel Markets Affected

HOV lanes provide travel time savings and trip reliability improvements that act as an inducement to carpooling. A form of HOV lanes, called High Occupancy Toll (HOT) lanes, would allow single occupant drivers to “buy into” the HOV lanes when they are underutilized and access the travel benefits above. The feasibility of the HOT lanes depends on the location and forecasted carpool lane utilization, which determines the available lane capacity to accommodate new HOT users. Since most HOV lanes are operated as such during the commute hours, the primary market would be work trips.

Background

The region currently has 298 lane miles of HOV lanes (including freeways and expressways). In its most recent HOV Master Plan update, MTC analyzed new HOV lane concepts and the relative regional emission reductions for different HOV lane configurations: an expanded HOV system; expanded HOV system with express bus; HOV lanes converted to 3+ occupancy requirements; 3+ occupancy for carpools with conversion of select mixed flow lanes to HOV together with express bus service. The summary results of this analysis are contained in the Appendix. The report did not, however, look at High Occupancy Toll lanes from an air quality perspective.

A subsequent analysis identified the corridors with the highest potential for HOT conversion. The total distance of this HOT network would be 200 miles, with a potential 13,800 new HOT users over the 2 hour a.m. peak in the year 2010.

Methodology and Key Assumptions for Calculations

High Occupancy Toll lanes operate on the principal that there is capacity to “sell” to single occupant vehicles that desire to save travel time. Thus, the critical factor is where the HOV system is forecasted to have excess capacity in the future (the optimum use of HOT lanes would be about 1,600 vehicles per hour to maintain a travel time advantage over the mixed flow lanes). MTC’s travel demand model forecasts for the year 2010 were used to determine where this excess capacity exists. Allowing single occupant vehicles into the HOT lanes will reduce traffic in the adjacent mixed flow lanes, which will then result in improved speeds and changes in motor vehicle emissions. Key potential HOT corridors were identified as portions of:

- I-580 (eastern Alameda County)
- I-680 (Alameda and Contra Costa Counties)
- US 101 (Marin and Sonoma Counties)
- Portions of US 101 (San Mateo and Santa Clara Counties)
- Route 4 (Contra Costa County East)
- Route 85 (Santa Clara County)

Emission Reductions.

- **0.0659** tons per day VOC
- ***increase*** of **0.0959** tons per day NOx

Reductions in VOC occur because of overall improvements in corridor travel speeds; however, these same speed improvements would lead to higher emissions of NOx.

Cost Effectiveness

Converting an existing HOV lane to HOT, would be the least expensive way to implement HOT. The MTC study conducted for the US 101 Corridor in Sonoma County showed an incremental cost of about $120,000 per mile for non-HOV lane construction items (signs, toll readers, pylon barriers, etc). On the high cost end would be the construction of new HOT facilities, such as new lanes and direct HOT-to-HOT connectors at major interchanges. In a recent study, The Reason Foundation has estimated the cost of a 630 mile integrated HOT network in the Bay Area to be about $4.5 billion (including expensive new aerial HOT facilities).

The cost of the more limited HOT network described above, would be far less because it would use several existing HOV facilities. For the purpose of this analysis, the HOT lanes are allocated half the cost of constructing new HOV facilities (since there would be traditional HOV users as well) plus the cost of converting existing HOV lanes to HOT, or about $200 million. The HOT lane revenues are assumed to cover the administration and operating costs (this is a conservative assumption since past studies indicate some HOT lanes may also be able to pay for significant portion of the construction cost).

This measure would have to be evaluated as a VOC control strategy only, since higher freeway speeds overall increase NOx more than the measure would reduce VOC.

- Cost per ton of VOC reduced: $595,500 per ton ($298 per pound)

Assumptions: 30 year annualization factor for capital costs (.05102); 260 workdays a year

Other Benefits/Impacts

HOT lanes would improve the operational efficiency of the freeways by making use of unused HOV lane capacity and providing travel time savings to those willing to pay. This in turn, provide benefits to vehicles in the adjacent mixed flow lanes as well. Any HOT revenues that remain after servicing construction debt could be used for new transit or carpooling options in the corridor with the HOT lane.

Measure : $3 Bridge Toll

Description/Travel Markets Affected
Raising the toll on all seven (7) state-owned bridges would reduce auto driving to some limited extent, as some trips would be shifted from toll paying to less costly transportation options, such as BART, bus or carpooling, depending on the bridge. The level of mode shift would depend on the amount of the toll increase. This analysis is based on tolls increasing from $2 to $3. Both work and non work trips would be affected by the toll increase.

Background
SB 916 (Perata), signed by the Governor, will allow Bay Area voters do determine in March 2004 whether tolls should be increased to pay for a specific set of projects in an associated expenditure plan. The tolls will also pay for the operating costs of some of the new transit services, such as ferries.

Methodology and Key Assumptions for Calculations
The analysis only addresses the impact on travel behavior of the toll increase itself, and does not address the complimentary effects of investing these revenues in new transportation improvements and services. Research using MTC's travel demand model indicates that toll vehicle elasticities vary by bridge and are higher in the peak period than the off peak period. While higher tolls do impact driving costs, Transbay auto use is fairly inelastic with respect to toll increases. MTC's research shows an elasticity for regional vehicle trips of about -.029, meaning that for every 100% increase in tolls, regional vehicle trips would *decline* 2.9% (vehicle trips across the Bay would decline by a higher percent, but Transbay travel in aggregate only consititutes about 4% of all daily regional trips). A $3 toll would represent a 50% increase in the current toll of $2. For the purpose of the analysis it was assumed that the typical Transbay auto trip is 20 miles. The emission calculations also account for new motor bus emissions as former auto users are shifted to transit.

Emission Reductions.

- **0.0522** tons per day VOC
- **0.1051** tons per day NOx

Cost Effectiveness
Not applicable, as measure does not require any capital or operating funds.

Other Benefits/Impacts
As mentioned above, higher bridge tolls will help fund other road and transit improvements that directly benefit the bridge corridors. The expenditure plan for Regional Measure 2 on the March 2004 ballot lists these improvements.

Measure : Regional Gas Tax

Description/Travel Markets Affected

Increasing the tax on gasoline would affect all vehicle trips made throughout the region, and even small changes in travel behavior and auto use could have significant cumulative effects. Changes in gasoline prices at the pump would affect all trip purposes.

Background

MTC has been granted authority by the State Legislature to seek voter approval of a gas tax increase of up to $0.10 per gallon for 20 years. At current prices for regular gasoline ($1.65 per gallon), a 10 cent increase would be about a 6% increase in price. A regional gas tax would fund a set of eligible projects and programs identified in an associated expenditure plan which has not been developed. Periodic polling conducted by MTC shows that it would be difficult to obtain approval for a gas tax increase, given the current requirement for a 2/3 voter approval margin to put an increase into effect.

Methodology and Key Assumptions for Calculations

The methodology is similar to that for the bridge toll increase, and relies on price elasticities derived from MTCs' travel demand forecast model. The calculated elasticity from MTC's travel demand model is –0.036, indicating that a 10% increase in gas costs would generate a 0.36 percent decrease in regional vehicle trips (as gas prices increase in the future, the impact of a constant 10 cent tax on driving will diminish, since the regional gas tax is not adjusted for inflation). Calculations were made to account for the offset emissions which would be generated by the need for additional buses as trips are shifted from autos to bus transit.

Emission Reductions.

- **0.7018** tons per day of VOC
- **0.4040** tons per day NOx

Cost Effectiveness

Not applicable, as measure does not require any capital or operating funds.

Other Benefits/Impacts

As mentioned above, new regional gas tax revenues would be used to will help fund a set of transportation improvements that have not yet been defined, but which would have to meet certain eligibility criteria specified in the enabling legislation. The improvements generally would allow revenues to be used for most types of transportation projects with the exception of new mixed flow road capacity.

Measure 14: Parking Charges at Work Sites

Description/Travel Markets Affected

Currently most private employer parking is free and treated as an employee benefit. A small number of spaces (those that are leased by a company) are subject to parking "cash out" provisions in state law. Significant changes in travel behavior have been documented in several locations where employee parking was provided free and then changed to a paid parking. Depending on the options available at the specific work location, charges could result in increased use of transit (if convenient and available), formation of additional carpools (to reduce the cost to the individual), or increased use of non motorized travel by employees living close to work (bike/walk). There are many variations on how parking charges could be applied, such as a basic hourly charge, reduced charges for carpools, air pollution adjustments reflecting emission characteristics of the employee's vehicle, etc. The primary market would be work trips.

Background

The impact of parking charges on travel behavior has been evaluated by MTC in a theoretical manner on several occassions. Of the 3.7 million jobs in the Bay Area, MTC estimates that about 82% of these jobs are located in MTC defined travel analysis zones with no parking costs. MTC's most recent evaluation of parking charges on regional scale was performed as part of the 2000 *Transportation Blueprint for the 21st Century*. The results below are based on this study.

Methodology and Key Assumptions for Calculations

Using the *Blueprint* analysis, the relative impact of additional parking charges can be determined. In this analysis a daily charge of $2.60 was added to all work parking spaces (i.e., a space that is not currently charged would have a daily fee of $2.60, whereas a space that does have a charge would have $2.60 added to the price). This pricing assumption affects auto operating costs in the regional travel demand model, which then results in mode shift changes. Overall, it was found that regional vehicle trips and VMT would be reduced by 0.7% ..The emission calculations below account for the offset emissions from additional buses as trips are shifted from autos to bus transit.

Emission Reductions.

- **0.8187** tons per day VOC
- **0.4713** tons per day NOx

Cost Effectiveness

Not applicable, as measure does not require any capital or operating funds that can be estimated at this time.

Other Benefits/Impacts

Parking charges would presumably be used to fund commute alternatives for employees paying for the parking, either in the form of commute allowances, shuttles to transit, vanpool subsidization, or contributions to the local transit operator for more convenient service.

Measure 15: Bike Storage at Rail Stations

Description/Travel Markets Affected

Having adequate bike storage at rail stations in the form of lockers or racks is an essential element in increasing bike access to transit. The demand for secure storage is increasing, given the cost of some of the newer bicycles. Most rail stations have some bike storage which could be expanded to various degrees. Storage tends to be used most by commuters who leave their bikes at the station all day. The markets are both work and non work trips.

Background

This measure evaluates the air quality benefits of expanding BART's bike storage system, including lockers and racks. About 2% of the access trips to BART stations are currently made by bike, and BART provides 2,716 spaces for bicycles in racks and 819 locker spaces.

Methodology and Key Assumptions for Calculations

The emissions analysis assumes all spaces are used on a daily basis, and that the bike trips replace a car access trip. The assumptions below would generate the maximum emission reductions.

- BART is adding 1,200 new bike storage units
- 5 mile trip length between home and transit station
- Vehicle fleet mix: 90% LDVs and 10% SUVs

Emission Reductions.

- **0.0450** tons per day VOC
- **0.0487** tons per day NOx

Cost Effectiveness

The cost of a bike locker is about $750 and the cost of a rack is about $100 per space. Assuming the new bike storage is added in proportionate amounts to the existing space, the cost would be $301,000.

- Cost per ton of VOC and NOx reduced: $2,330 per ton ($1.17 per pound)

Assumptions: all bike racks are occupied on a daily basis; five year annualization factor for bike storage at 0.22, and ridership annualization for BART of 303

Other Benefits/Impacts

Shifting station access trips to bikes can relieve pressure for providing expensive new auto parking. Bike use can also lessen traffic around stations.

Measure 16: Safe Routes to Transit

<u>Description/Travel Markets Affected</u>
This measure would focus on the routes used to access rail stations and key transit centers by biking or walking. The intent of the measure would be to increase pedestrian and bicycle access to through safer and more convenient access. Concerns with current routes range from personal safety to physical obstacles that make bike and walk access to stations difficult or impossible, to adequate signage. Both work and non work trips are potential markets.

<u>Background</u>
Safe Routes to Transit has been promoted by several Bay Area advocacy organizations. The concept is modeled after very successful programs in Japan, Germany, and the Netherlands to increase the use of bicycles to transit. Regional Measure 2 (RM2), if approved by Bay Area voters on the March 2004 ballot would raise bridge tolls by $1 and dedicate some of the money for a Safe Routes to Transit program. About 25% of the access trips to BART stations are currently made by biking and walking. This measure evaluates the air quality benefits of increasing bike/walk access to BART.

<u>Methodology and Key Assumptions for Calculations</u>
The assumptions are similar to those for the bicycle storage measure. For this measure it is assumed that pedestrian and bike access to BART would increase 20% above current levels due to route access improvements. It was further assumed that these new users would have previously driven a car to the station (although they may have used transit as well). The emission benefits below would increase to the extent that the improvements to the bike and walk routes actually caused people to use transit for their entire trip, but we did not factor this change into the emission benefits due to the lack of empirical data that would connect access route improvements to shifts in travel behavior).

- Increase in bike/walk access to BART from 25% to 30%; affects 6,250 trips a day
- 3 mile trip length

<u>Emission Reductions</u>.

- **0.0358** tons per day VOC
- **0.0279** tons per day NOx

<u>Cost Effectiveness</u>
Individual project costs for route access improvements can range from the low hundreds of thousands of dollars to several millions for new bike bridges and tunnels. The costs below are for improvements in routes to BART stations from the information submitted for RM 2.

- Capital cost of bike/ped improvements for BART stations: $45,000,000
- Cost per ton of reduction of VOC and NOx: $509,080 per ton ($255 per pound)

Assumptions: Five year annualization factor for capital cost; BART rider annualization of 303

Other Benefits/Impacts

Shifting station access trips to biking and walking can relieve the pressures on providing expensive new parking. Public safety will be improved. Bike/walk access can also lessen traffic around stations.

Measure 17: Station Cars at Transit Stations

Description/Travel Markets Affected

Station cars would allow transit patrons another travel choice for getting to dispersed destinations around transit stations (work related businesses, shopping, schools, residential areas, etc.). The concept would be to develop pods of Station Cars located at or near transit stations that could be reserved by riders to make short trips to and from the transit station.. The cars themselves would be low emission vehicles. Technological advancements would make it possible to reserve cars "on the fly" and to track cars as they are being used. Air quality benefits would accrue to the extent that the availability of the station car program influences travelers to use transit for their trip instead of driving. The markets affected are both work and non work trips.

Background

MTC analyzed the station car concept as a Further Study Measure in the 2001 Ozone Attainment Plan. There have been several pilot programs for station cars, but no recent expansion. In 2003 Caltrans requested applications to fund deployment of station cars in different parts of the state. MTC worked with the transit operators to develop a proposal, but funding shortages prevented Caltrans from moving forward. It is assumed that the administration of a regional station car program would be performed by an existing carsharing provider, rather than the transit operator. The following calculations illustrate the emission impacts of such a program.

Methodology and Key Assumptions for Calculations

The analysis of emission benefits is based on a 1,000 station cars distributed to various BART, Caltrain, and light rail stations

- Each car generates "new" transit trips, i.e., replaces trips that were formally made by car:
- For work trips, a scenario would be:
    1. A person uses their own car or transit to get to the rail station in the morning
    2. They pick up a car at the destination end of the trip and use it to get to work; they keep the car all day (possibly using it for errands in the mid-day) and return it to the station in the evening.

- For non work or work-related trips:
    1. A person uses their own car or transit to get to transit
    2. They pick up a car at the destination end of the trip and return it when done.

- Assume 800 station cars are for work trips and 200 cars are for non-work trips
- Vehicle mix for station car fleet: 50% SULEV and 50% ZEV
- Vehicle mix for cars replaced: 90% LDVs and 10% SUVs
- 100% cold start modes for 800 Station cars
- 5 mile trip length for Station Car travel from transit station to workplace

- 16 mile work or other trip length replaced by "new" transit trip

- Each of the 200 Station Cars are used 5 times a day
- 1 out of the 10 daily Station Car uses is assigned a cold start emission factor, the other 9 daily starts are assigned an average start emission factor
- Station Cars are replacing one trip chaining event for each person's work-to-home journey (i.e., to run an errand on the way home from work)
- One-way 5 mile trip for Station Car non work travel from transit station to errand location
- Average 30 minutes vehicle rest time while errand is being conducted

Emission Reductions.

  - **0.009** tons per day VOC
  - **0.018** tons per day NOx

Cost Effectiveness

Based on work performed for Further Study Measure 5 in the 2001 Ozone Plan the cost would be:

  - Vehicle cost (1,000 cars): $15 to $26 million, depending on technology
  - Parking infrastructure (charging for electric vehicles): $7 to $22 million
- Administration cost: $ 5 million per year

Assuming the mix of Station Car vehicle types above, the total program capital cost would be $32 million.

- Cost per ton of VOC and NOx reduced: $1,715,000 per ton ($857 per pound)

Assumptions: Five year annualization of capital costs at 0.218; 260 work day annualization for emissions.

Other Benefits/Impacts

Indirect benefits include raising the visibility of the carsharing concept among the larger Bay Area population. Transit riders would likely perceive the program as an improvement in the quality of transit service by providing more convenient access choices.

Measure 18: Carsharing

Description/Travel Markets Affected

Carsharing allows people to have access to a car without owning one by becoming a member of an organization where people can rent cars and pay only for the amount of time they actually use them. This arrangement avoids much of the overhead costs of car ownership (depreciation, insurance, repairs, etc.). Major expansion of existing carsharing programs could, over the long term, change travel behavior and driving habits through reduced household vehicle ownership. The markets are both work and non work trips, although surveys of current carsharing participants show more use of cars for non work trip purposes (personal business and social recreational trips).

Background

The largest Bay Area carsharing program is operated by, City CarShare which currently has over 2,800 members. City CarShare members are predominately located in San Francisco, and to a lesser extent in Berkeley and Oakland. Many of City CarShare members (2/3) come from carless households; therefore, they use carsharing to obtain greater convenience and save time over trips formally made by biking, walking, or transit. For those households that own a car(s) and are thinking about purchasing an additional car(s), future emission benefits may occur if overall household travel is less than would take place if the household acquired another vehicle(s) (this aspect of future travel behavior is the most difficult to ascertain).

Methodology and Key Assumptions for Calculations

Calculating emissions under various carsharing scenarios is not straightforward, given the multiple types of uses involved. For people that do not own a car, carsharing creates additional vehicle trips and miles of travel. For those who do own cars, carsharing may substitute for ownership of additional cars and lower long term household vehicle activity. Emission benefit calculations are further complicated by the emission characteristics of the carsharing vehicle relative to other modes that would have been used for a member's trip. Therefore, we have analyzed several scenarios using, to the extent possible, results from a recent City CarShare survey.

1) Base Case: Existing carshare vehicles (subcompacts) and use characteristics (emission characteristics of City CarShare vehicles are relative to the average Bay Area fleet)
2) Scenario 1: Super Low Emission vehicles: assumes carsharing vehicles are very clean
3) Scenario 2: Zero Emission Vehicles: assumes no emissions from carsharing vehicles

Other key assumptions are listed below:

- Expanded Carsharing penetration equal to 0.5% of all residents in San Francisco, Oakland, Berkeley (26,000 households)
- 67% of members are from carless households; 20% from 1-car households; 10% from two car households; and 3% from household with more than 2 cars

- Carsharing used for 8% of trips in all households
- 67% of these trips add vehicle trips by carsharing vehicles; 33% substitute trips for other vehicles as described in "1" to "3" above
- For the 33% of trips, assume the vehicle not used is 5 years old
- Average trip length of 6 miles

Emission Reductions.

- A range of **0.0439** to **0.0600** tons per day VOC
- A range of **0.0422** to **0.0569** tons per day NOx

Cost Effectiveness

It is not possible to develop a reliable cost effectiveness calculation given the complexity of the travel behavior and number of assumptions required.

Other Benefits/Impacts

Carsharing may reduce parking requirements for new residential and commercial development, if available at or near the new development. As mentioned above, participation could lower personal ownership costs associated with second or third cars, and provide indirect increases in household income.

Measure 19: Signal Coordination

Description/Travel Markets Affected
Signals control the flow of traffic on major streets. They can either be coordinated along a route or operate independently. Coordination of signals along an extended route can reduce stop delays and increase overall average speed. This in turn has a positive impact on emissions. The trips affected include both work and non work trips.

Signal coordination efforts have long been recognized as a way to improve the flow of traffic on local arterials and conserve energy. A recent before and after study of retiming 223 signals in San Jose, involving 28 separate signal systems, showed the following results:

- 32.6% reduction in average stopped delay
- 30.8% reduction in stops
- 16.1 % reduction in travel time
- 14.5% reduction in VOC
- 5% reduction in NOx

This measure would include coordination of signals that are not currently coordinated but have the potential for coordination based on their proximity to an existing coordinated signal(s).

Background
MTC's arterial database shows that there are approximately 7,000 signals in the Bay Area, of which about 3,500 are coordinated. MTC and the Air District have funded a number of projects to upgrade signal software, coordinate signals, retime signals, and help jurisdictions develop traffic management centers to control larger signal systems. MTC has also worked with a number of jurisdictions to develop Smart Corridors employing the latest signal management technologies.
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Methodology and Key Assumptions for Calculations
Of the total number of signals in the Bay Area, MTC estimates that there are currently 1,250 signals are not currently coordinated but have the potential for coordination. Coordination of these signals would bring the total number of coordinated signals in the Bay Area up to 4,788 (68%). Key assumptions would be:

- Average daily traffic on arterial is 10,000 which affects 3,200,000 daily miles of travel on local arterials
- Increase in average daily speed from 17.9 mph to 21.6 mph
- ROG emission factor reduction equal to –0.088 grams per mile
- NOx emission factor reduction equal to –0.079 grams per mile

Emission Reductions.

- **0.310** tons per day VOC

- **0.279** tons per day NOx

Cost Effectiveness

The cost of signal coordination is about $1,500 per signal, for a total cost of $1.9 million for coordinating 1,250 signals. This measure assumes regular timing updates of all existing and newly coordinated signals to preserve their effectiveness under MTC's TETAP program.

- Cost per ton of VOC and NOx reduced: $2,710 per ton ($1.35 per pound)

Assumptions: Five year annualization factor of 0.22; no loss in effectiveness from changing traffic conditions since signal timing would be routinely updated through MTC/CMA programs; 260 work days during the year

Other Benefits/Impacts

Retiming signals has been shown to be an effective fuel conservation strategy as there are fewer vehicle starts and stops and less idling at intersections. Retiming plans can also improve pedestrian and bicycle safety.

Measure 20: Roundabouts

Description/Travel Markets Affected

Roundabouts allow traffic to flow continuously through an intersection without the delays caused by signalized intersections. Traffic enters the roundabout at different points, merges with other traffic and exits the roundabout at the desired location without stopping. Local street intersection capacity is increased because there is no stopping of vehicles or loss of time due to the amber phase. Emissions are lowered because there is no vehicle stopping, idling, or acceleration involved.

Background

While common in Europe, only a handful of US cities have installed roundabouts. Roundabouts arrived in the US around 1990, and as of 2000 there were about 300 in existence. In the United Kingdom (UK), where roundabouts have been employed extensively, the number of roundabouts and traffic signals are about the same. UK roundabouts generally have two to four lanes and tend to be on higher volume streets compared to the US. Capacities of up to 8,000 vehicles per hour have been achieved in the UK. While roundabouts may work in some traffic conditions better than signals, retrofitting roundabouts into an existing street intersection may present design challenges and could require additional right of way.

Methodology and Key Assumptions for Calculations

Estimating the emission benefits from roundabouts using existing traffic planning tools is difficult without knowing the specific location, design, and traffic conditions. Further, future applications would likely be at isolated intersections rather than in a large areawide deployment, limiting the overall regional emission potential. The analysis therefore is based on a literature search of technical papers addressing the traffic and air quality benefits of this type of intersection treatment.

Emission Reductions.

The following information was obtained from a literature review:

- The emissions for stopped vehicles are about 4-5 times greater than slowly moving vehicles.
- Emission studies cited in the literature have indicated reductions in VOC and NOx in the range of 30% to 50%, depending on how the base conditions are defined (i.e., an intersection with stops signs, an isolated intersection with signals, or a signal that is part of a larger coordinated signal system)
- Signals would create stop and go conditions during the off peak, when they may not need to; roundabouts would operate efficiently throughout the day.

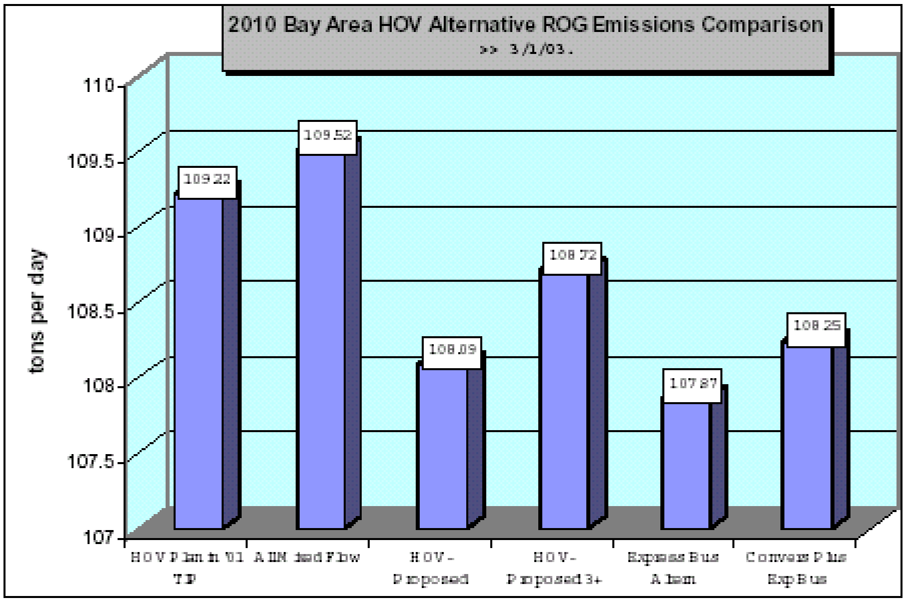
Cost Effectiveness

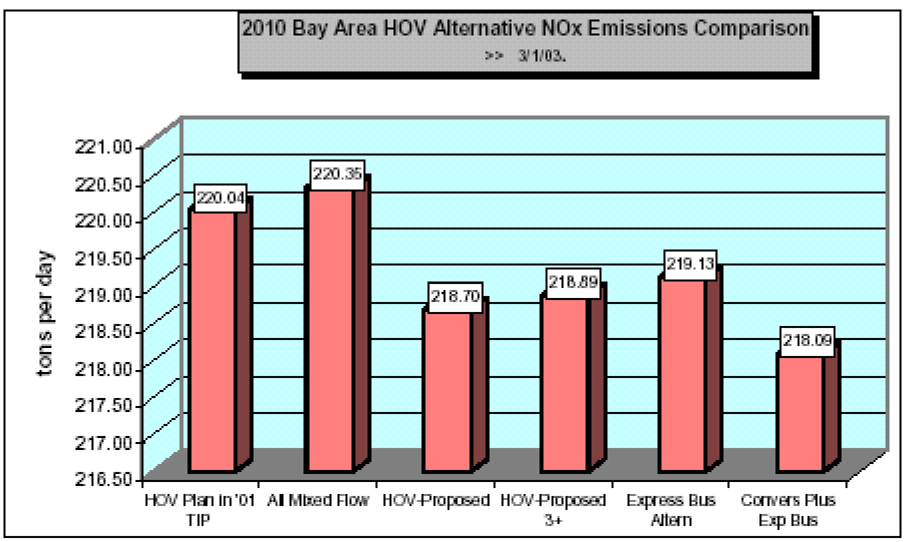
- Not calculated. .

Other Benefits/Impacts

Roundabouts provide significant safety benefits as well as traffic benefits because they constrain the speed of vehicles using the roundabout and because they eliminate accidents where two cars collide at 90 degrees (the most serious type of accident). The Insurance Institute of Highway safety found that roundabouts reduced total crashes by 39% and injury crashes by 76% when they replace a traditional signalized intersection. From a pedestrian and bicycle user perspective, roundabouts require people to wait for gaps in the traffic and then use different islands as temporary refuge areas while they wait for the next gap in traffic. Finally, because of their traffic flow benefits roundabouts reduce fuel consumption, Carbon Dioxide, and Carbon Monoxide compared to signalized intersections.

Appendix 1
Summary of HOV Lane Emission Reductions





Appendix 2
Comments on other TCM Suggestions

Introduction

A number of suggestions have been received from the public relating to TCM-type measures or air quality planning process issues. A number of these suggestions cannot be readily analyzed in terms of expected emission reduction of ozone precursors, which is the focus of the current ozone planning work. In the spirit of the exercise, we have provided responses to this more diverse set of public comment, categorized under several main topics:

- Planning Process
- Funding
- Smart Growth land use
- New Authority
- Conditioning of funds
- Other

Planning Process

- Major Investment Studies should include a land use alternative that provides for densification around transit stops, similar to the LUTRAQ alternative studied in Portland, Oregon.
- Suggest MTC convene a peer group review panel to assess how well the MTC travel forecasting models capture latent demand and are sensitive to bike and pedestrian travel with Smart Growth type land uses.
- Develop level of service indicators for all modes, including aspects of Safety, Times for Total Trips, Convenience and Pleasure trips, integration with other modes, and impact on the environment.
- Improve the quality of government decision-making. Provide research and support for analysis of major investments suggested by the public.

Responses

After several years of regional collaboration, a Smart Growth land use alternative was adopted by ABAG and will be used as the basis for updating MTC's long range regional transportation plan and for individual transportation corridor studies. Also, MTC's Major Investment Study guidelines (prepared by MTC and the Bay Area Partnership in response to the original ISTEA major investment study requirements) encourage study managers to look at complimentary land use changes for any new transportation investment. While the federal planning requirement for Major Investment Studies was eliminated in the latest transportation reauthorization bill (TEA-21), all new transportation studies initiated in the region will be using the regional agency's Smart Growth assumptions now incorporated into ABAG's *Projections 2003*.

MTC has already developed a list of potential refinements to the regional travel demand model that will be implemented in connection with the *Transportation 2030 Plan*. These refinements will help to better capture the effects of Smart Growth land use changes on future travel behavior. Later on, when MTC begins the next major update of the regional travel demand model (most likely in the Summer/Fall of 2004), MTC will work with representatives of FHWA and FTA in a peer review of the current model. Among other items, this peer review will address both Smart Growth modeling issues as well as the latest thinking in the modeling community on induced demand.

Regarding level of service measures, a number of efforts are underway to rethink the way transportation system service levels are defined and used to inform decisions about future transportation investments (for example, ongoing work by the San Francisco Transportation Authority). A Smart Growth workshop was recently conducted exclusively on this topic.

Finally, the ongoing Transportation 2030 planning process has engaged in extensive public outreach, including solicitation of ideas from the public on new transportation projects and programs, which they would like to see MTC evaluate. Under SB 1492, MTC is now required to evaluate the performance of transportation projects for possible inclusion in the financially constrained portion of the long range plan. MTC will be evaluating projects submitted by the public that pass certain screening criteria. This is the first RTP process to do so.

Funding

- MTC should allocate CMAQ funds separately, based on cost effectiveness, from other fund sources because they are supposed to be used to improve air quality.
- Focus CMAQ funding on light and heavy duty vehicle incentive programs.
- Amend ACA 4 to permit funds allocated to the State or County to be flexed into transit projects.
- Set transit ridership targets and use funding to achieve these.

Responses

CMAQ funds are already being used in large part to advance the region's strategies to improve air quality, including Spare the Air, MTC's Regional Express Bus program, retrofitting of urban buses to reduce pollution, TLC/HIP, local bike/ped projects, and TransLink®, as examples. The allocation of funds solely on the basis of their cost effectiveness would exclude other important policy considerations from the allocation process. As the name implies, CMAQ funds are intended for both congestion mitigation and air quality activities.

In terms of heavy duty vehicle programs, MTC has recently allocated CMAQ funds to retrofit 1,700 urban buses with devices to control particulates and NOx. To the extent that VOC reductions continue to be the most effective control strategy to reduce ozone, the funding priorities will focus on this task (heavy duty vehicles are generally producers of NOx because they use diesel engines). Significant VOC reductions continue to be achieved through the state standards for automobile engines which result in continuing annual declines in emissions as older cars are replaced with newer, cleaner vehicles.

We believe that ACA 4, which shifted the sales tax component of the state gasoline tax from the General Fund to the state transportation fund, already provides significant flexibility for transit. This transfer was approved by voters in 2002 and is distributed: 1) 20% to the Public Transportation Account for transit, 2) 40% to local governments to maintain local streets and roads (which are used by buses), and 3) 40% to the state highway account (STIP), which includes rail transit construction as an eligible use of funds.

With regard to setting transit targets, the best response is the amount of funding currently dedicated to the support of public transit in MTC's long range plan (over 70%), which exceeds that of any other regional transportation plan around the country (source: FHWA). MTC is charged with developing a transportation plan and investment strategy that balances funding among a range of travel needs throughout the region. Dedicating even more funding to transit, which currently serves 6% of daily regional trips, would create funding shortages in other important regional and local programs. Also, as has been noted in the past, the chief constraint to expansion of transit is the lack of new operating funds which are largely locally generated. Finally, transit ridership growth bears a much closer relationship to factors beyond MTC's control (e.g. the economy, gasoline prices, land use densities, etc.) than to the amount of public funding dedicated to developing and subsidizing new transit service.

Smart Growth

- Commit a specific percentage of funds to Smart Growth incentives, including TLC and HIP.
- Prepare a parking manual that provides alternative parking standards for new development near transit or development that incorporates carsharing or various commute alternatives programs that would reduce auto use (e.g., a residential Ecopass program)
- Retroactively relieve commercial development from parking requirements based on experience with Commute Alternative programs.

Responses

MTC's primary incentive program for linking transportation and land use has and continues to be the TLC/HIP program. The current update of the regional transportation plan --Transportation 2030 – includes funding of TLC/HIP at the tripled levels from the last plan. Within this amount, MTC will be exploring the creation of an incentive program to spur development of local specific plans for Transit Oriented Development around transit stations.

MTC has submitted a grant application for Caltrans planning funds to prepare an Alternatives Parking Manual addressing the concepts described above. If successful in obtaining this grant, MTC believes the work would be valuable for not only the Bay Area, but other local jurisdictions around the state who are engaged in Smart Growth discussions.

The third suggestion would, if implemented at the local level, allow businesses to use land currently dedicated to parking for future expansion of their operations. This would be allowed where there is evidence that commute alternatives programs can provide a sustainable reduction in long term parking demand. Thus, the concept can best be pursued at the local level on a case by case basis, using direct experience with specific commute alternatives programs.

New Authority

- Adopt a Regional Transportation Impact Mitigation Fee
- Local jurisdictions should implement a parking tax on employers, based on the number of spaces they own.
- Implement congestion pricing on the Bay bridges and use the surplus revenues to fund transit passes for low income travelers.
- Adopt local ordinances that would unbundle leasing costs for parking

Responses

The concept of a regional transportation impact fee is similar to traffic mitigation fees at the local level. As proposed, the concept would lead to higher fees on suburban development due to their traffic burden on the regional transportation system and would make urban infill development more competitive in the marketplace. Without further evaluation, the concept raises several conceptual issues: 1) the one time fee would not effect travel behavior of individuals on a daily basis, 2) the fee would add to the already high cost of housing, 3) the fee may duplicate similar existing sub-regional fees, and 4) the long term air quality benefits from land use changes (presuming the fee contributes to such changes) are not nearly as significant as the contribution from ever cleaner automobiles.

Parking fees, while a proven factor in changing travel behavior, remain an elusive control strategy. Employers benefit by offering free parking (recruitment and retention of employees) and have few incentives to charge their employees, particularly given the employee relations aspects. Local jurisdictions do not want to antagonize employers that are beneficial in many ways to their community. Retailers see parking as a way to attract customers, and neighborhoods fear parking spillover due to lack of space, or in the case of parking fees, people trying to find free parking away from the employment site. Thus, while the theory is sound, the practical and political barriers are substantial.

Legislative approval would be necessary to implement congestion pricing on one or more of the Bay bridges. While, regional agencies have consistently expressed their interest in at least testing the concept of congestion pricing, to date they have not been able to secure Legislative support (the most recent effort being in connection with Regional Measure 2 on the March 2004 ballot). MTC will continue to evaluate congestion pricing concept in order to be prepared for future opportunities that may arise. Any congestion pricing program would necessarily address the potential for adverse impacts on lower income Transbay travelers and develop remedies.

Conditioning MTC Funds to Local Jurisdictions

Conditioning of various federal and state funds by MTC to local cities has been suggested as a strategy that could be used to achieve one or more of the following outcomes:

- Require cities and counties to plan for and implement Smart Growth (higher densities, more concentrated development near transit, etc.)
- Require local parking requirements to conform to regional parking standards
- Require cities to implement Commuter Choice for their employees
- Require cities to make employers provide economic incentives to their employees to reduce trips
- Require cities and counties to impose conditions on new development to reduce trips.
- Require cities to adopt Green Contracting Ordinances to have contractors to the city use new, low emission equipment

Response

In general, the only realistic public policy approach at the regional level to affecting changes in local actions has been that of offering incentives (e.g., MTC's existing Transportation for Livable Communities and Housing Incentive Programs) rather than to attempt to regulate or condition funds. The incentives approach makes even more sense given the fact that the Bay Area has already made substantial air quality progress, achieving the national 1-hour ozone standard and only marginally exceeding the new national 8 hour ozone standard. Nevertheless, the topic of using MTC funding authority for non transportation related outcomes was discussed at great length in 2002/2003 as part of a California Air Resources Board (ARB) stakeholder process initiated in connection with their approval of the 2001 Ozone Plan. These meetings also discussed at length an October 26, 1999 letter from the Air Resources Board to MTC concerning MTC's authority to implement TCMs based on whether certain criteria were met, particularly consistency with the RTP. While not fully resolved in this process, all parties agreed that there are certainly limits in terms of how far MTC can realistically stretch its existing statutory authority to mandate change in non transportation areas.

Several important considerations having to do with conditioning funds to local jurisdictions for air quality, trip reduction, or land use changes include the following:
1) whether it is possible to quantify emission reductions from land use changes in a rigorous enough way to estimate or claim SIP credits; in the context of this ozone planning exercise, the case would need to be made that there is a strong nexus between conditioning of funds and measurable reductions in ozone precursors.
2) whether the conditioning of funds would indirectly establish trip reduction requirements on employers, either municipal or private (which would be inconsistent with state law),
3) whether, if local governments already have the authority to impose trip reduction requirements on new development, there is any compelling reason for MTC to intervene in this local land use decision process
4) whether the conditioning would create conflicts with other regional transportation policies and priorities, i.e., would it make sense to withhold funds to a local jurisdiction to repair potholes (maintaining the transportation system is one of the key regional priorities), if a jurisdiction is not taking actions to reduce employee trips and implement Smart Growth plans and zoning?

5) whether, from a practical standpoint, the amount of funding controlled by MTC and potentially available to local jurisdictions is large enough to have any effect on the decisions of over a 100 Bay Area cities and counties

The Ozone Working Group asked for more information on the kinds of funding that MTC controls which goes to local jurisdictions and the amount of this funding. The response to this request in based on the current Transportation 2030 Plan analysis as well as analysis of funding in MTC's current three Transportation Improvement Program (TIP). First, it must be remembered that there are many different transportation funding sources, and local governments are eligible to directly receive funding from only a few of these.

A substantial amount of the funding flows to transit operators:

- FTA Section 5307 and 5309 (MTC allocates):
- FTA Section 5310 and 5311 (MTC allocates)
- Federal earmarks (Congress allocates)
- STP/CMAQ (transit rehabilitation and other projects-MTC allocates)
- State Transit Assistance – (MTC allocates only the population based portion)
- AB 1107 funds to BART and Muni (funding defined by statutory formula)
- Local county sales taxes (funding defined in voter approved expenditure plans)
- Certain Regional Measure 1 Bridge tolls (for buses and ferries-MTC allocates)
- TCRP (project list defined by legislation; may be eliminated due to state budget crisis)
- Transit funds in the STIP/RTIP (funds flow to counties by formula-MTC programs RTIP funds in the STIP)
- Transit funds in the STIP/ITIP (the California Transportation Commission allocates ITIP funds)
- RM2 Bridge tolls (funds directed according to expenditure plan-various types of project recipients)

A substantial amount of funding flows to Caltrans' highway projects:

- Highway funds in the STIP/RTIP (funds flow to counties by formula-MTC programs RTIP funds in the STIP)
- Highway funds in the STIP/ITIP (the California Transportation Commission allocates ITIP funds)
- SHOPP (State Highway Operations Protection Program-the California Transportation Commission allocates)
- Local sales tax funds (county transportation authorities control funds)
- STP funds (MTC allocates)
- Regional Measure 1 funds- Bridge improvement funds for seven state owned bridges directed by a voter approved expenditure plan.

Some federal/state funding flows to MTC's regional programs which MTC manages:

- Translink, 511/TravInfo, regional ridesharing, Roving Tow Trucks/Freeway Call Boxes, transit trip planning, signal retiming, etc (some of these programs are TCMs in federal and state air quality plans)

- TLC/HIP (TCM is federal and state air quality plans)

The main sources of funding for local projects are:

- Bicycle/pedestrian projects (these are TCMs in federal and state air quality plans): TDA Article 3; STP/CMAQ; local sales tax funds from county expenditure plans
- TLC/HIP (MTC allocates—see above)
- Local street repair: State gas tax subventions to local cities (gas tax funds directed to cities by formula); federal STP (MTC allocates)
- Other local street improvements: County sales tax revenues from voter approved expenditure plans, federal STP(MTC allocates)
- Planning funds(CMAs): STP funds (MTC allocates to county Congestion Management Agencies for local planning purposes, including land use (T-PLUS program).
- Other local/city funds

Appendix 4 details the funding amounts for these various sources based on the most recent analysis for the 25 year Transportation 2030 Plan.

We next look specifically at the amount of funding included for local jurisdictions over the three year period covered by the current Transportation Improvement Program. The amount of funds MTC could possibly condition to local jurisdictions is the summation of the following categories:

- STP (exclusive of regional programs, transit rehabilitation, and planning funds)- the remainder would include funds for road rehab and some minor amount of funding for road improvements
- CMAQ (exclusive of regional programs and transit related)- the remaining amount of funds is very minor
- Transportation Enhancements (TEA)-MTC portion. Generally goes back to counties for bike/pedestrian projects and TLC/HIP projects

These sources are shown below in terms of the uses and amounts for the FY 03-05 funding period.

Funding to Local Jurisdictions in the TIP (Fiscal Years 2003-2005)				
Category	**STP**	**CMAQ**	**TEA**	**Total**
TLC/HIP	$9,197,500	$470,000	$1,334,000	$11,001,500
Bike/Ped	$380,721	$6,780,000	$5,812,749	$12,973,470
Local Roads	$37,833,900	$12,088,000		$49,921,900
CMAs/Rideshare/Other	$11,195,951	$7,600,000		$18,795,951
Total	$58,608,072	426,938,000	$7,146,749	$92,692,821

Thus, excluding the CMA/Other category, roughly $74 million goes to local governments, which is about 0.7% of the $10.1 billion in the TIP. And virtually all of this amount is going to projects that are air quality friendly or maintain the existing system.

This is not to imply that there are no circumstances under which MTC would condition funds. For example, in the current Transportation 2030 Plan update, MTC has proposed conditioning of federal New Starts funds for transit expansion based on the fact that a nexus does exist between expending transit funds and the need to develop local land use plans that will support the transit expansion through increased ridership (conditions on Resolution 3434 Transit Expansion Projects in the "Transportation and Land Use Policy Platform" for the Transportation 2030 Plan, December 2003). MTC is also developing an approach for conditioning highway funds on the incorporation of key regional system management elements in the highway projects.

Other Comments

1) Develop rail and transit hubs with generous bike facilities instead of massive auto parking space.
2) Establish 2-person instead of 3-person carpool requirement for the new Benicia Bridge and review carpool occupancy requirements on other Bay bridges for seamless regional HOV connections.
3) Continue carpool lane over the Bay Bridge
4) Fund free bus passes for students.
5) Replace noisy, polluting buses with more frequent service by smaller and cleaner buses and vans.
6) Have public agencies implement parking charges at agency owned public parking lots.
7) Remove signals on the Richmond Parkway in order to reduce pollution from trucks as they accelerate from stop at a local intersection onto the Parkway.

Responses:

1) MTC studied opportunities for expanding bike storage at a number of transit centers as part of the evaluation of Further Study Measure 5 in the 2001 Ozone Attainment Plan. MTC's ongoing Transit Connectivity Study will also identify a group of important regional transit hubs and suggest a menu of expanded passenger amenities for these hubs, including bike facilities.
2) It is unlikely that changing occupancy requirements on a single bridge would have regional air quality impacts, nor would changes in traffic conditions at the toll plaza likely affect air quality readings at the Concord monitor, which is located some distance from the toll plaza. One commenter notes that the financial issues (loss of toll revenues) associated with changing carpool occupancy requirements from 3+ to 2+ over the Benicia Bridge should not rule out this suggestion from further consideration, as financial concerns did nor rule out evaluation of other TCMs. However, in this case the change would affect existing bonding covenants to pay for bridge improvements, which is not a speculative financial impact, but a real one. This factor distinguishes the issue from other more general types of financial and cost effectiveness information presented. In terms of

looking at occupancy requirements on the other Bay Bridges, this issue was addressed in MTC's most recent HOV Lane Master Plan update study, completed February 2003.

3) The suggestion to provide a continuous carpool lane over the Bay Bridge for carpools and buses was study extensively in MTC's Bay Crossings Study. Both Caltrans and MTC's consultants concluded there would be significant adverse operational impacts on bridge traffic from dedicating a lane all the way across the bridge for this purpose. The current carpool/bus bypass lanes on the bridge approaches and at the toll plaza and resulting time savings will continue to be the most significant inducement to carpool and bus transit use.

4) MTC and AC Transit established a pilot program to evaluate the use of student passes for improved attendance and participation in after school activities. A total of 25,000 free bus passes were distributed to low-income students attending middle or high schools located within AC Transit's service area, which covers all of Alameda County and western Contra Costa County. This represented about two-thirds of the students eligible to receive the pass; those enrolled in the Free or Reduced Lunch (FRL) Program. Six school districts out of a total of seven participated in program, with most free passes being distributed in the Richmond and Oakland School Districts. In order to learn about students' travel patterns, researchers evaluating of the program administered a survey the year prior to initiation of the free bus pass program (2002), and again during the spring of 2003, once the program had been in place for most of the school year. The results of survey did not indicate there would be significant reductions in emissions from the program.

5) A number of efforts are underway to reduce pollution from urban buses, including the program funded by MTC to retrofit 1,700 buses with devices to lower particulate matter and Nitrogen Oxides. The air quality implications of running a greater number of smaller buses have not been analyzed, but the current shortage of transit operating funds would make such a strategy infeasible.

6) The evaluation conducted under Further Study Measure 4 in the 2001 Ozone Attainment Plan showed that over 80% of existing municipally provided parking space is already charged. Thus, the additional air quality benefit from charging the remaining space would not likely be significant, and there may be other local reasons for not charging this space.

7) From a historical context, the Richmond Parkway was developed as a way to remove truck traffic from neighborhood streets, and was initially called the "North Richmond Bypass". The Parkway was constructed largely with local transportation sales tax funds, and was built as an at grade facility with signalized intersections. There are 18 intersections on the Parkway itself and 3 on South Garrard. Truck movement in West Contra Costa County has been studied extensively and most recently in a report titled *Truck Route/Weight Limitations Survey for West Contra Costa County* (Dowling and Associates, December 2001). The survey showed that about 25% of all truck movements in West Contra Costa County occur on the Parkway. Grade separating the at grade signalized intersections, so that some trucks would not need to stop at intersections, would be very costly (probably over $10 million per intersection), and there would not be sufficient local or regional funds to accomplish a comprehensive grade separation project. A more practical approach, at much lower cost, might be to identify trucks that routinely

use the Parkway and retrofit these trucks with emission control devices that lower particulate emissions (and perhaps Nitrogen Oxides, which contribute to ozone).

Appendix 3
Figures 1 – 8

Figure 1

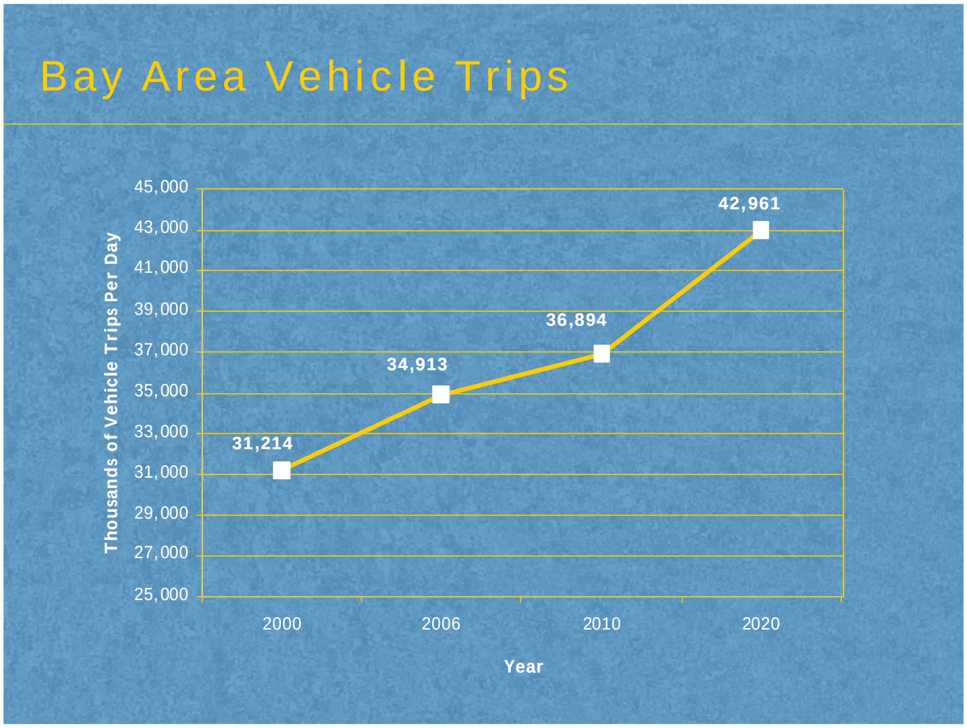
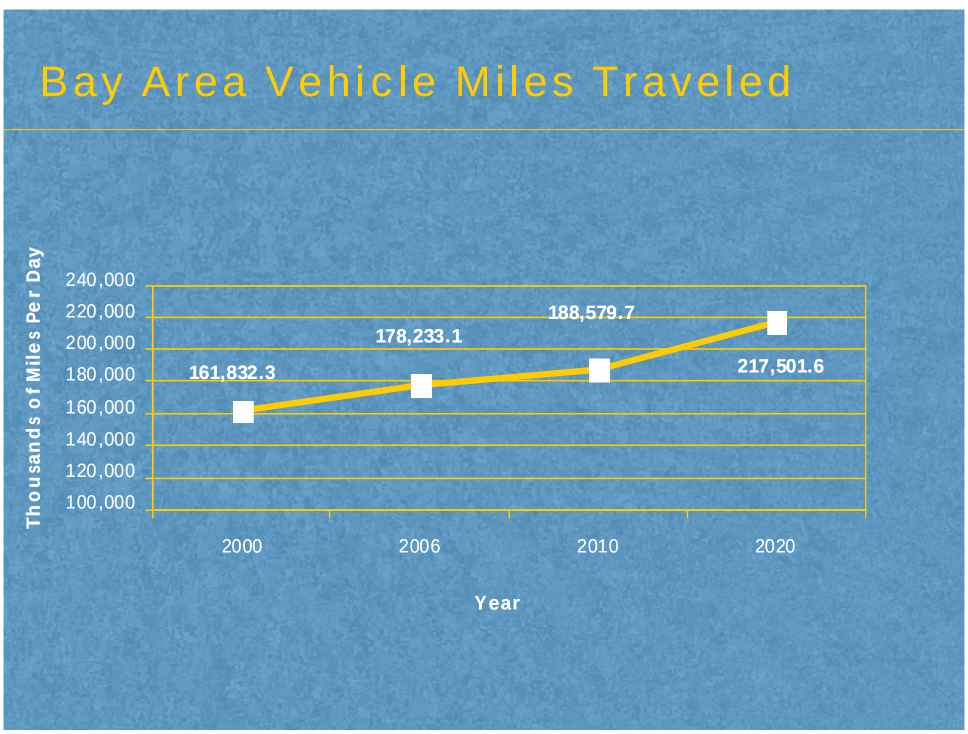


Figure 2



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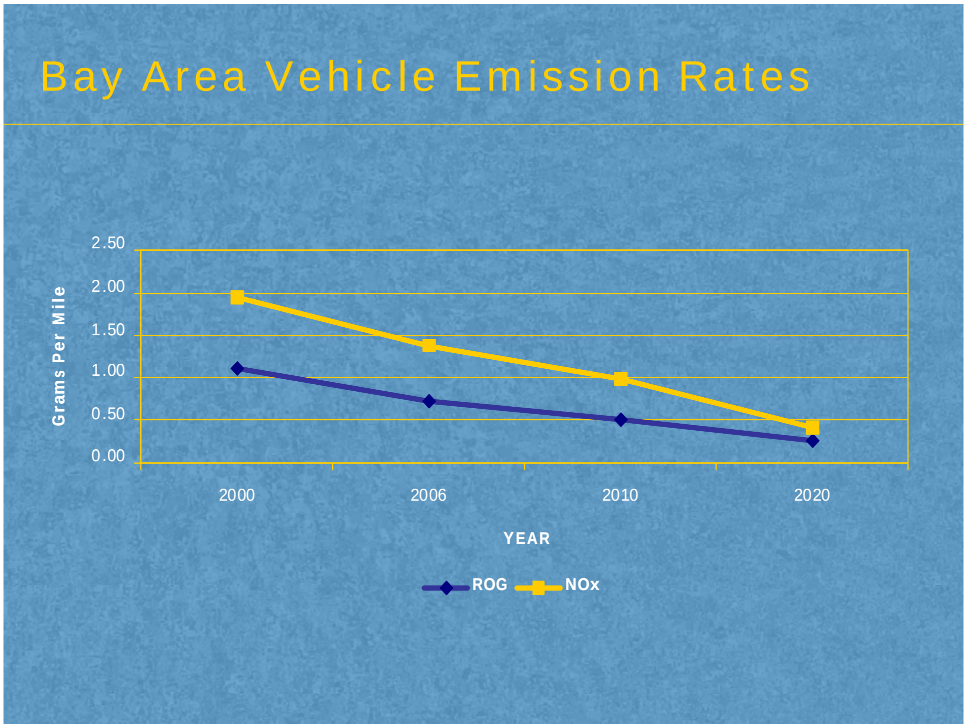

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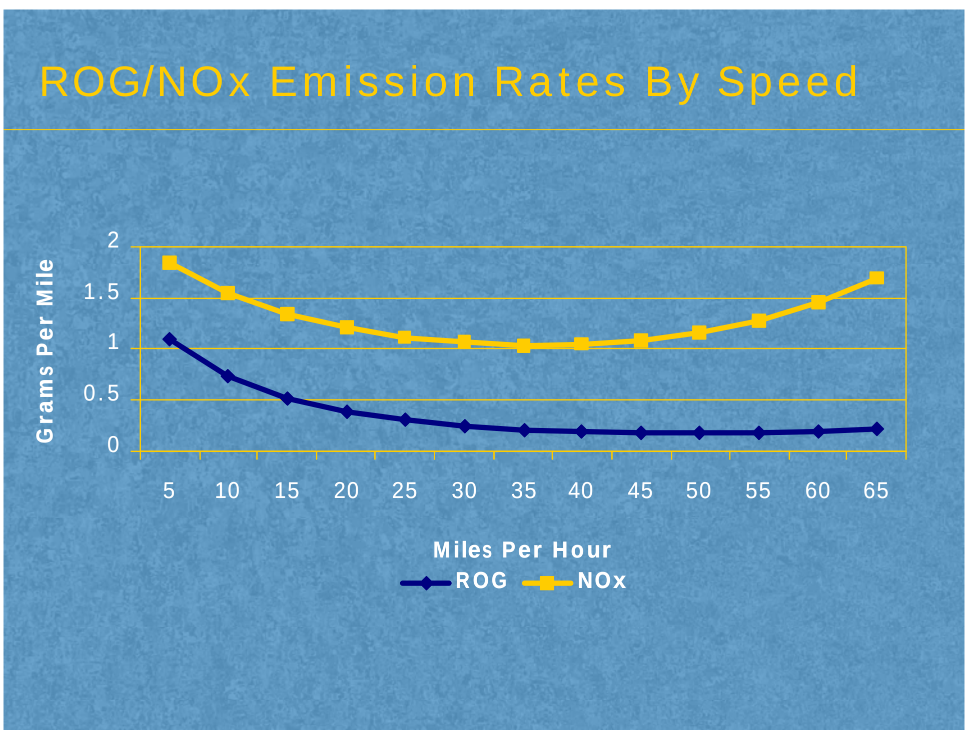

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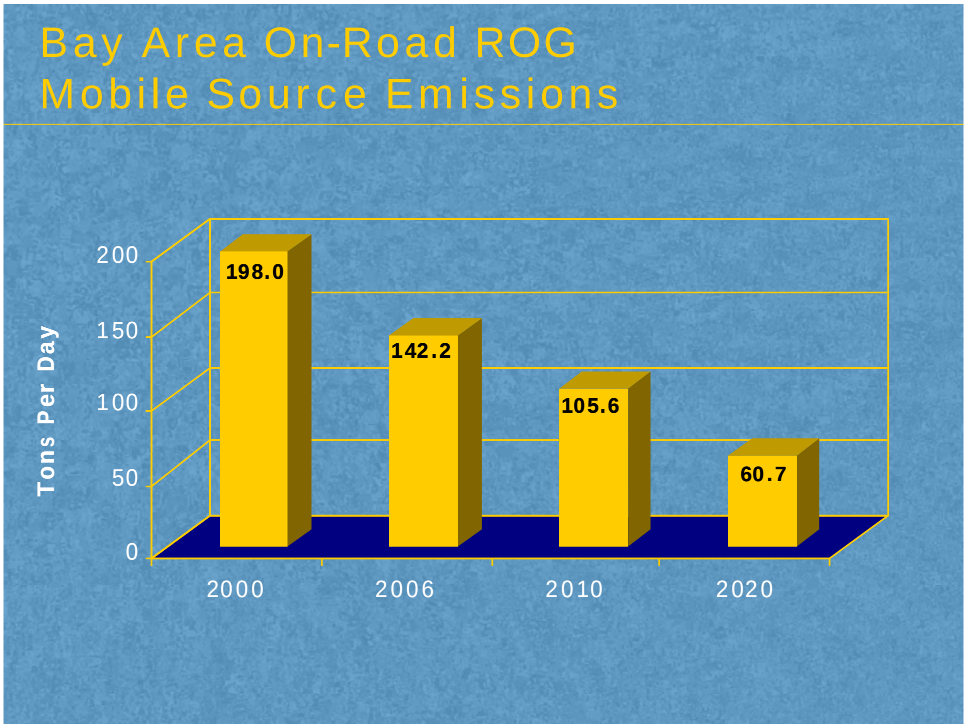

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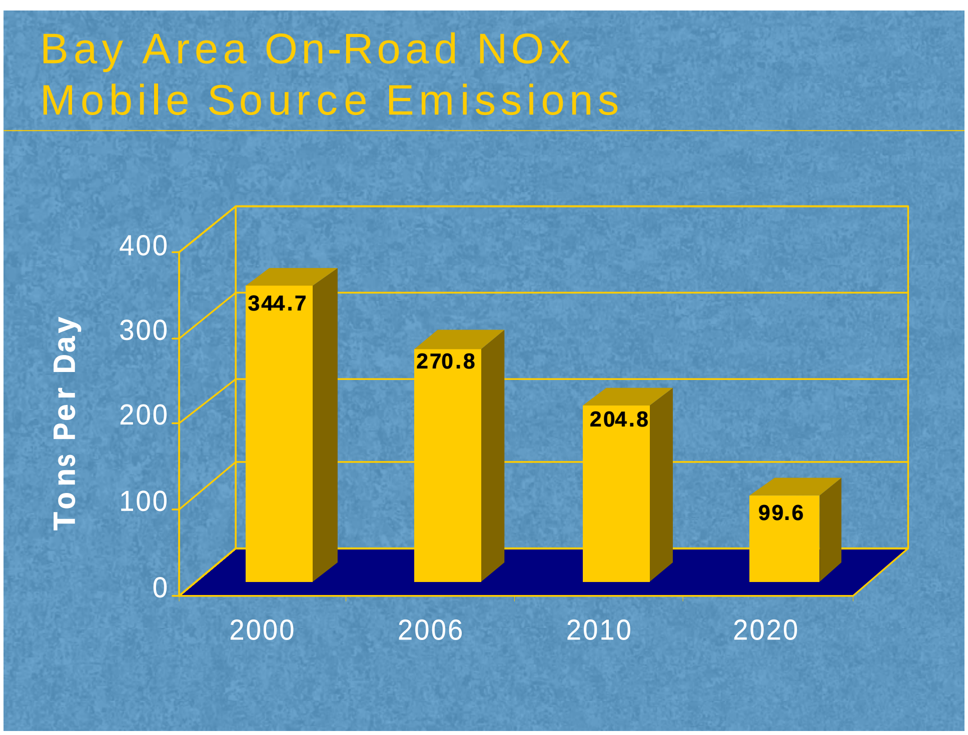

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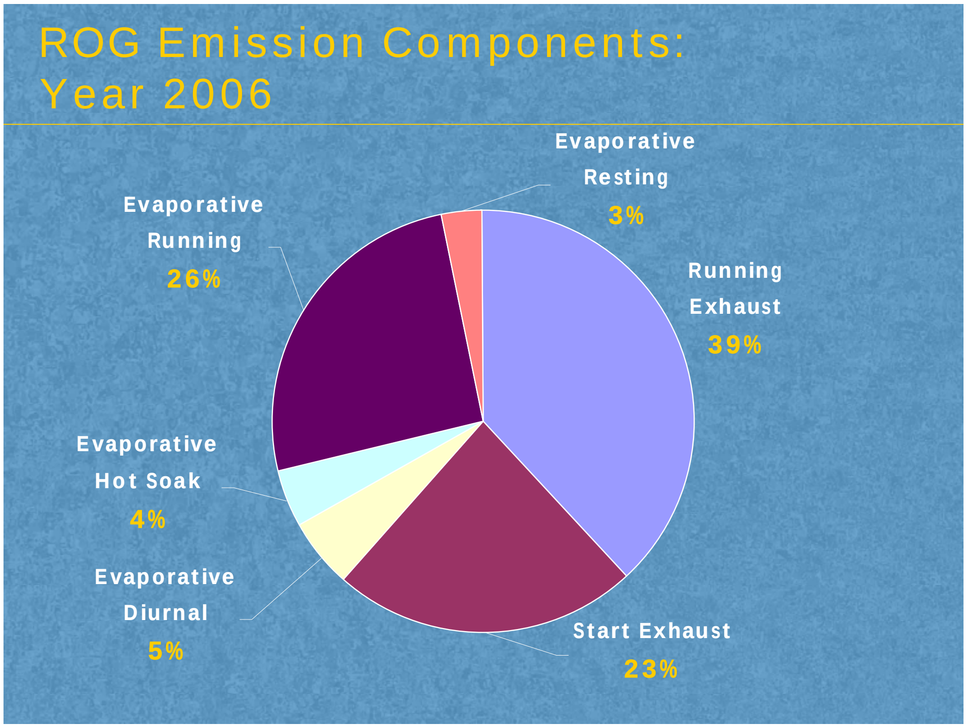

Figure 8